Cushing (E. W.)

THE SPECIFIC

AND

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INFECTIOUS CHARACTER

OF

TUBERCULOSIS.

Compliments of

BY

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THE SPECIFIC AND INFECTIOUS CHARACTER OF TUBERCULOSIS, WITH EXHIBITION OF THE BACILLI OF TUBERCULOSIS, AND THOSE OF MALIGNANT PUSTULE (ANTHRAX).[1]

BY E. W. CUSHING, M.D., OF BOSTON.

In considering the etiology of tuberculosis, facts have often been observed suggesting that it is infectious, and, in fact, the question was discussed here some years ago, when many cases were related, supporting this theory. But, although this view is very old, and has long been popular in some countries, especially in Italy, yet it certainly never took firm root in the profession until recently, when Professor Koch furnished proof of the directly infectious nature of the disease. I have been asked to give a summary of the evidence on which his decision rests, and shall therefore make a free use of his work on the subject, published in the last communications of the German Imperial Health Office. Although the question will seem rather threadbare to many of you, the importance of the subject is so great that I ask you to bear with me while I go over this ground, as requested.

To determine this question of infectiousness there are three courses possible, either first to rely on clinical facts — and these have never been clear enough to convince the profession; second, to study the subject in the light of pathological anatomy; and third, to try to get light from experiments. The second method has given us many facts, notably, that miliary tuberculosis generally can be traced to preëxisting caseous de-

[1] Read before the Section for Clinical Medicine, Pathology and Hygiene of the Suffolk District Medical Society, November 11, 1885.

posits, showing an auto-infection; in some cases the direct manner of the general dispersion of the tubercles can be seen, as shown by Ponfick, to depend on the introduction of tuberculous matter into the thoracic duct, or as observed by Weigert, where similarly the wall of a bloodvessel allowed a direct introduction of caseous deposits into the general circulation. An auto-infection was thus demonstrated, but the cause of the original disease was not explained.

The method of experiment was used by Klenke in 1843, to show that rabbits could be made tuberculous by inoculating into them the sputa, or fragments from the lungs, of tuberculous patients, and these experiments were improved and extended by Villemin, Klebs, and others. But, on the other hand, it was shown that animals died from similar affections after the injection of fragments of powdered glass, etc., and it was long before it was demonstrated that in such cases where the creatures were really tuberculous, it was owing to the contamination of the matters injected with the virus of other tubercular animals, or to the infection derived from keeping them in confined localities with other creatures already affected, or in cages where such had been affected with the disease.

It is now well known that no animal can be made tuberculous by substances which have been properly sterilized, and which are inoculated under proper antiseptic conditions.

The clearest and prettiest example of infection was furnished by the experiments of Cohnheim and Salomonsen, who inoculated the anterior chamber of the eye in rabbits with material from tuberculous subjects. This experiment has the great advantage that spontaneous tuberculosis of the eye in rabbits never occurs, and that the whole process can be watched, as the

little tubercles form on the iris, become caseous, and infect the whole eye; then they creep along the lymphatic vessels, and infect the glands of the neck, and thence the liver, lungs spleen, etc. No substance not from a tubercular source, or which has been sterilized, will do this, and the demonstration of infection is complete.

That chapter is closed, and it remains to find out the nature and properties of the cause of the infection.

This might either be something formed in or from the body, organized or unorganized, or a parasite from without, living in the diseased tissues, and reproducing itself there.

As no one had ever been able to find or demonstrate a virus of the first kind, it seemed reasonable to search for one of the second, and it is the great honor and service of Koch to have solved this problem.

He was led up to his discovery by the analogy of infectious processes everywhere, as best exemplified by anthrax or malignant pustule. As this is the very type and sample of infectious diseases I will be somewhat more explicit.

If the blood or organs of an animal dead of anthrax be examined with a reasonably good microscope, it is found to swarm with little rods, single or jointed together, but having no proper motion. This is an invariable accompaniment of the disease, but not therefore necessarily its cause. It is found, however, that they grow readily on gelatine mixture, or boiled potato, and by various processes of coloring the cultures so produced, these rods are seen to enclose spores.

Now the smallest scratch on a healthy animal if inoculated with the blood of one suffering with anthrax, will set up the disease in the former, if of a species susceptible of it, and with fatal effect, and when it

dies, the rods are found in its blood, or organs, as I here show you, having lost none of their peculiarities. Still it might be said that the rods did not cause the disease, but some other product contained in the blood set up the infection, and rendered the infected animal a fit soil for the growth of harmless parasites. But if these rods be bred, say on potato, from one generation to another, taking each time a very minute portion on a needle for seed, it is plain that after a few generations nothing is left except the bacilli, and not even any of those which came from the first diseased animal, but only their remote posterity or descendents. Here I show the rods in a pure culture, many times removed from the first, and showing a network of chain-like rods, jointed together like chains, and containing spores which do not take the color.

Now the smallest portion of a culture like this inoculated into an animal, of a susceptible species, will set up the disease in all its original virulence, showing that the bacilli or rods are the cause and not merely the accompaniment of the disease. The actual poisoning is supposed to come from a chemical virus which they excrete, but the exact manner of their action is not essential; we say they cause death as we say that a bullet causes death when shot into the chest, without necessarily knowing the exact way in which it acts. Practically no one doubts this virulent activity in the case of anthrax; it cannot be explained away, there is no chance for error, and it naturally points the proper course for experiments with other diseases.

Koch, therefore, set himself to find out whether there exist in the blood, organs, or sputa of the tuberculous any formed elements not belonging to the body, or derivable from its tissues.

If such were found, to determine whether they had

motion, or other signs of life, such as reproduction, subdivision, formation of spores, etc.

Whether they could be cultivated outside the body, and isolated by repeated cultures, and, if so, whether they alone are capable of causing the disease, as the bacillus anthracis causes anthrax.

Now Koch was not the first who had thought of this; many had looked for bacteria in tuberculosis, but had not found them. A common microscope will scarcely show them, when stained, far less find them uncolored among the morbid tissues.

Remembering that the addition of potash to analine dyes facilitates the coloring of certain bacteria, he tried an alkaline solution of methylene blue, and was fortunate enough to get the bacilli tuberculosis faintly stained, and found that, very luckily, when the preparation is put into a brown solution of vesuvin, the bacilli stay blue and the other substances present become brown. The process of staining was afterwards modified and improved by Ehrlich, Weigert, and others, and carried to the precision of a chemical reaction, so as to distinguish infallibly between the tubercle bacilli and any others yet discovered.

The only bacilli liable to cause confusion are those of lepra and of syphilis, and where doubt might exist, which is very seldom, there are means of distinguishing them, which we need not enter on here.

The method at present recommended by Koch, probably the surest, is as follows : aniline water is prepared fresh by shaking five ccm. of pure aniline oil with 100 ccm. of distilled water, and filtering well through a wet filter paper, to make a clear solution. To 100 ccm. of this is added 11 ccm. saturated alcoholic solution of methyl violet or of fuchsine and 10 ccm. of absolute alcohol. This solution will keep for about ten

days if well stoppered. In this solution fine sections of organs hardened in absolute alcohol must lie twelve hours or more; fluids dried and baked on to cover glasses can be stained in ten or fifteen minutes by heating the solution nearly to boiling. The preparations are then put for a few seconds in a twenty-five per cent. solution of nitric acid, until they lose most of their color, and well washed in sixty per cent. alcohol. They are then stained in a dilute solution of vesuvin (for methyl violet) or of methylene blue (for fuchsine) washed again in sixty per cent. alcohol, have the water taken out by absolute alcohol, are cleared up by cedar oil, and can then be examined microscopically, or if desired can be preserved in Canada balsam.

There is nothing very difficult in all this for one who has a moderate skill in using a microscope and making preparations, but of course it takes a little time, and some patience to learn to handle the colors properly, so as not to decolorize too much, nor smother the bacilli in the contrasting color.

Sputa can be kept in a stoppered vial for weeks, if necessary, without injuring the bacilli, or can be dried in a thin layer upon covering glasses, by squeezing a drop between two glasses, sliding them apart and drying them well. They can thus be kept for a long time until occasion offers for a proper examination. But even when stained and prepared it requires a good microscope to see them, and especially to find them in tissues. To work at all satisfactorily a microscope is necessary, having a large condensing lens underneath, which concentrates a flood of light from all sides on the colored bacilli, at the same time rendering all the tissues indistinct and hazy by abolishing all shadows.

Moreover, it is desirable to have a good oil immer-

sion object-glass of one-twelfth or one-sixteenth, giving a magnifying power of 700 to 1000. With such a microscope I show you bacilli from tuberculous sputum and from the secretion of a little cavity in a lung, also in the tissue of the same lung, and in a tuberculous larynx.

In the lung I show you, with a power of only fifty, the bacilli lying in a mass so dense as to give a red blot on the pale blue ground, and by a higher power you can see the individual bacilli; a slight motion of the adjusting screw causes them to appear to squirm as various layers rapidly pass into and out of the focus.

I exhibit also the plates of the work of the Imperial German Health Office above referred to, showing how they lie singly, or a few together, in the giant cells, which have long been noticed as characteristic of tubercle, apparently imprisoned there; how they lie in dense masses in the walls of cavities, around small arteries, in the kidneys, etc. You also see here representations of the organs of animals dead of acute general tuberculosis, from inoculation or inhalation, of which I will speak presently.

Here, then, is our specific bacillus; it remains to see first, if it is always present; second, if it can be bred and isolated; third, if it can cause the disease; and fourth, if anything else can set up tuberculosis. To settle these points long series of experiments have been carried on, covering years of precise and conscientious labor, of which I can only cite a few from the book you have in your hands, merely stating that I have seen many of them repeated, and have repeated some myself, and I heartily believe in their entire accuracy and fairness.

To detail even a fraction of the experiments connected with this investigation, would take me far be-

yond the limits of this paper; I can only sketch methods and results, referring you to the original reports for judgment as to the thoroughness and accuracy with which they are made.

The bacilli were sought and found in all manner of tubercular products both in man and in animals. They are from one-fourth to one-half the diameter of a red blood corpuscle in length, and relatively in thickness about in the ratio of pieces of a common lead pencil which has been cut into three or four pieces. But absolutely it is the length and not the thickness of the bacilli which varies. They carry spores from four to six in each bacillus, when they occur, but they are not always found. In cheezy masses they are seldom found, either because they are not there, or because like the spores, which never take up the color, they cannot be stained. That the spores at least are present in the cheezy masses is shown by the highly infectious properties of the latter when inoculated into animals.

It is interesting to find that the bacilli are always precisely similar, whether found in man or animals, in miliary tubercles, in sputum, or in cavities, in scrofulous glands, so called, or in tuberculous joints. Even in lupus, the bacillus is in no way different, and can be bred in cultures, and when so bred and inoculated into animals it promptly sets up general tuberculosis.

The bacilli have no proper motion, and in their migrations they are carried along by wander-cells and so pass into the lymphatic system. The cells which carry them soon lose their properties, and either are arrested and surrounded by epithelioid cells, or, as Koch thinks more probable, they are deformed and changed to giant cells, enclosing their bacilli.

I will not weary you by rehearsing the different kinds of cases of phthisis, and scrofula, in which bacilli

have been demonstrated. Koch describes the examination of nineteen cases of miliary tuberculosis of various organs, in all of which bacilli were found, and in no case were they wanting. In twenty-nine cases of pulmonary phthisis examined they were in no case absent, and this fact is of great importance as opposed to the view of those who hold that a large class of cases of phthisis are independent of bacilli, and that the latter are only an accidental complication of an existing disease.

Of course the fact that bacilli are not found in the sputa is no evidence that they are not present in some parts of the lung, not opening directly into a bronchus. Even in a post mortem examination it requires a real expert in a doubtful case, to select the portions of lung to be searched microscopically, and even in the same little piece not every cut may have bacilli.

But admitting that cases do occur where phthisis exists and no bacilli can be found in the sputa, they are *very rare* when due diligence is used, and, on the other hand, where the bacilli are found it is a clear proof of tuberculosis.

In scrofulous glands and joints, which show the characteristics of tubercle, namely, collections of epithelioid cells or giant cells, the bacilli were found in all cases examined, namely: twenty-one cases of scrofulous glands and thirteen of scrofulous joints.

This does not deny that the glands may undergo enlargement from other causes and macroscopically simulate scrofula. In four cases of lupus where sections of the skin were examined, the bacilli were always present, although in one case twenty-seven cuts, and in another forty-three cuts, had to be searched in order to find the bacilli. Even in one of these cases pure cultures were bred in serum, which, when inocu-

lated into animals in the anterior chamber of the eye, set up tuberculosis, as likewise did the fresh matter in every one of seven cases.

From the various cases mentioned above, and from many others occurring in man or animals, there were inoculated, or infected, a total of five hundred and nine small animals, of various genera, which died tuberculous, and in these, without exception, the bacilli were found in the tubercles.

In general, then, in all cases, human or animal, which showed both in their history and on microscopic examination, that they were truly tubercular, there were found characteristic bacilli, showing a peculiar and distinctive reaction with aniline colors. The whole number was so large that this could not be accidental. To be precise, there were two cases in the whole number in which the bacilli could not be found directly, namely, the pus of a nephritic abscess, and the pus of an abscess arising from caries of the vertebræ. In both these cases, however, the pus caused tuberculosis when inoculated into animals, and, doubtless, if the kidney or the vertebra could have been searched, the bacilli would have been found in them. Moreover, all sorts of diseases in men and animals were carefully studied, but in none were the above bacilli found except in true tubercular processes.

Secondly. The presence of the bacilli characterizes the inception of the disease, it is the first step in the formation of the tubercle; it is found that the first collection of epithelioid cells, and of a giant cell, coincides with the deposit of a bacillus, the caseation comes later.

Thirdly, where the disease is active, the bacilli are numerous, and vice versa. When the phthisis is chronic they are few and scattered, when it ceases, and the

lesions heal, the bacilli disappear, both from the sputum and tissues.

Koch insists that these three facts, namely: "that the tubercle bacilli invariably and exclusively accompany tuberculosis; that, both in locality and time, they precede all the peculiar pathological changes of that disease; and that their number, their presence, and their disappearance, stand in direct relation to the course of the tuberculosis — that these facts permit us to conclude, with great probability, that the bacilli tuberculosis are no accidental accompaniment of tuberculosis, but that they stand in a *causal* connection to it.

But the question is so important that I shall ask you to listen to the further experiments made, as before suggested, in order to cultivate and isolate the bacillus, and to ascertain, with full certainty, its infectious properties.

Of course the first attempts to cultivate the bacilli were made with the ordinary mixture of meat, water, peptone and gelatine. But they did not grow, because the temperature at which the gelatine mixture ceases to be solid is far below that necessary for their development. Blood serum, however, when heated to 65° C., becomes solid and yet is transparent, or nearly so. First, however, it must be heated daily for five consecutive days to 58° C. for an hour, to kill all bacteria present as they come out of the condition of spores. On the surface of the serum, the particles of suspected tissue are laid, and the bacilli soon spread out in a thin white layer. Of this a minute particle is taken on a platinum wire, which has been heated previously to redness and then cooled, and is quickly laid on the surface of another layer of serum in a test tube, and this is then stoppered with cotton; after a few such transplantings it is certain that practically none of the original material is

left. Koch gives a table of forty-eight sets of cultures derived from all possible sources in tubercular men and animals.

There are also long series of experiments on animals made by inoculating the tuberculous tissues or cultures, or mixtures of them with water, into the eye, veins, peritoneal cavity, under the skin, etc., also infections by feeding and by inhalation. I will not detain you with these. In general, I may say that the lymphatic glands nearest the point of inoculation became swollen and caseous, and from them in time arose a miliary tuberculosis of the liver, spleen, kidneys, lungs, etc.

In the plates you will see the organs represented, covered with the miliary tubercles. I will only describe one experiment by inhalation, as this is the form of infection to which man is most exposed; it will also show the thoroughness with which the experiments were carried on. Culture No. 1 was obtained from human pulmonary phthisis, first by inoculation of a guinea-pig, thence planted in serum and carried for fifteen months in twenty-three transplantations. This was rubbed with distilled water and diluted until it seemed nearly clear. The upper clear part was decanted and used for inhalations by atomizing daily for three consecutive days, each time for a half hour, fifty cubic centimeters, into a cage containing eight rabbits, ten guinea-pigs, four rats, four mice. As it would have been too dangerous to do this in a house or to be in close proximity to the spray, the cage was placed in an open garden and the air was forced to the atomizer through a small lead tube run in through the casing of a window which was kept shut. After the inhalation, the animals were separated and put alone in roomy cages.

In ten days some of the animals had dyspnœa,

between the fourteenth and twenty-fifth days three rabbits and four guinea-pigs died. All the other animals were killed on the twenty-eighth day.

Every one of the twenty-six animals had tubercles in the lungs, and those who died latest or were killed had them also in their livers and spleens. The rats and mice being less susceptible had less abundant lesions, but there was no doubt about any of them. I show a picture from the lung of one of the rabbits, showing a cheesy pneumonia, quite similar to the spontaneous tuberculosis so-called of these animals which is really an infection by inhalation.

From these various animals, tuberculous matter was taken and inoculated subcutaneously on the bellies of twenty-two guinea-pigs. They all soon had swelling of the inguinal glands, and all died tuberculous in from five to eight weeks.

In the various inoculations and inhalations all the animals used, of susceptible species, two hundred and seventeen in number, became infected and died. A large number of other animals had similar inoculations performed with fluids free from the tubercle bacillus and none were affected; nothing else produced the specific disease except the tubercular matter, or cultures from it, the latter working more promptly.

All sorts of other bacteria were tried, with negative results, all errors were avoided, every care taken.

There is no escape from the conclusion that the third and fourth of the above mentioned questions are satisfactorily answered. Tuberculosis is to be classed in the category of infectious diseases, as much as anthrax. The bacilli tuberculosis are as much the cause of the former as the bacilli anthracis are of the latter.

The next point to consider is the manner in which bacilli are reproduced, and how they enter the body to

produce infection. Now as they will not breed at a temperature less than 30 C. or 86 F., it is evident that they cannot find this temperature enduring for weeks together, combined with moisture and an animal substance to serve for nourishment, except in the animal body during life. They are not, therefore, like the germs of anthrax and erysipelas, which are capable of living and breeding entirely separate from any animal organism. Every tubercular infection must come directly from some previously diseased person or animal. This can occur in three ways: *First*, by inhaling the bacilli or their spores, either in spray or dust derived from the sputa of the phthisical. *Second*, by inoculating wounds or scratches with similar material, causing a glandular tuberculosis or scrofula, which, when the original abrasion has healed, seems to have arisen spontaneously. *Third*, by swallowing meat or milk coming from tubercular animals.

In support of this view it is only necessary to recall the vast amount of matter expectorated by the phthisical, who comprise nearly one-seventh of civilized humanity. Experiments show that the bacilli do not lose their virulence in sputa which has been allowed to stand and putrefy for seven weeks, that when dry, they are infectious after six months. They have been demonstrated in the milk and even in the blood of diseased animals, and it is proved that tuberculosis can be induced in animals by feeding them with milk and other material from tuberculous animals. A case is on record where a phthisical wet nurse gave tuberculosis to three successive infants which she suckled.

All this, however, it will at once be observed, proves too much; why do we not all become infected, since we must all be exposed?

In regard to the milk and meat question, it is because cows' milk rarely becomes tuberculous unless the udder is diseased, and it so happens that this is seldom the case, for the tubercular nodules are usually confined to the lungs, or at least to parts not used as food, because rejected when manifestedly diseased. Moreover, the healthy stomach seems able to destroy the bacilli, even when not previously killed by cooking of the meat eaten. The bacilli, also, do not, as a rule, remain long enough in the intestines to acquire a lodgment. In phthisical persons, however, who swallow their own sputa to a certain extent, it not infrequently happens that the intestines become tuberculous by a real autoinfection.

As for infection from scratches, the great safety lies again in the long time required for the development of the tubercle bacillus, and perhaps in the low temperature of the outermost layers of the most exposed portions of skin. The question is not yet sufficiently examined to make it worth while to discuss it at length here.

However desirable it may be then to reform our meat and milk supply by proper inspection and regulation, practically the great source of tubercular infection is by inhalation, as is evident from the fact that the lungs are first attacked in the great majority of cases.

Here, again, the principal objection to accepting the theory of infection is the fact that we do not all die of the disease. But in the first place a great many do so die, so many that a scare over a little small-pox or even cholera seems absurd, in view of the fearful mortality of one in seven from phthisis.

Why do the rest escape? Because not only the seed is requisite, but the soil must be adapted to it; in

other words, there must be a predisposition, or at least a susceptibility.

Just as some species of animals are far less liable to "take" an infection than others, and individuals of the same species vary more or less, so in man certain persons and certain families, even certain races, show a marked immunity as compared with others who seem predestined for infection.

Not every child "takes" scarlet fever when exposed, nor measles, nor vaccination, so not every person "takes" tuberculosis. It must be remembered that the living and healthy organism fights against infections of all kinds of bacteria; it is not like a test-tube of serum; it has its own proper vital defences. Some of these we understand, some we do not. In regard to this specific infection, we observe at once the great advantage that it is to us that the bacilli do not reproduce themselves for ten or fifteen days, so that if the lungs are healthy, there is every chance that they will be caught and passed upwards by the ciliated epithelium until they can be coughed out; on the other hand, we see why infection so readily occurs when the cilia are damaged or lost, as after measles or catarrhal conditions, or when, for any reason, there are collections of secretions retained in the lungs, forming a nidus for the bacilli, or when, owing to imperfect development or deformity of the thorax, or pleuritic adhesions, the movements of the lungs are so restrained that foreign particles and catarrhal secretions are imperfectly and slowly removed.

Practically, therefore, it is found that infection usually only takes place where there is family predisposition, abnormal pulmonary or thoracic development, or pre-existing disease of the bronchial mucous membrane.

The other predisposing causes are apt to be intemperance, weakness, hunger, or close confinement in workshops or dwellings, where the system of previously healthy persons is reduced, and they are rendered susceptible to infection. Of course, if in addition to close quarters there is the presence of a tuberculous person continually coughing bacilli into the air, and covering the floor and furniture with spores which are frequently stirred up as dust, we have pretty accurately reproduced the experiment of the cage and atomizer to which I referred above. Who can wonder that under these circumstances the infection spreads in families and workshops?

But if a bacillus gains a lodgment and begins to breed, what follows? In susceptible cases, the same process goes on which we have followed in the rabbit's eye. The infection creeps along, carried by wander-cells from point to point, from gland to gland; the carrying cells are deformed to giant cells, surrounded by epithelioid cells. These become cheesy, large nodules form, caseate, break down, open into a bronchus and are expectorated, forming a cavity; often some of the secretion is aspirated into neighboring parts, and wherever it comes, sets up a cheesy pneumonia; sometimes, by passing into the bloodvessels or thoracic duct, the bacilli pass into the general circulation and set up a general acute miliary tuberculosis.

But all cases do not take this dismal course; sometimes nature triumphs over the invader. Man is not a rabbit or a guinea pig. In resistance to tubercular infection, as well as in other characteristics, he partakes of the peculiarities and privileges of his friend, the dog. In many cases then, the bacilli find that they are in an unfruitful soil. The wander-cells bearing bacilli are arrested, headed off by a general concurrence of leu-

cocytes; a barrier is formed around the budding tubercles, and they stay imprisoned until the bacilli die; or, if the mass is larger and cascates, and is expectorated, the boundary contracts, the bacilli diminish in numbers, fewer and fewer and finally none are found in the sputa, and the patient recovers, bearing in his lungs the scars that are so often found on autopsy.

From the frequency with which these cicatrices are observed, these cases of recovery must be very common, and often occur where tuberculosis was not suspected or diagnosed, or where, because the patient got well, the physician has been blamed for mistaking the nature of the malady, when he might have deserved praise for curing a case of consumption.

You all know how, in a broken-down cachectic subject, a common micrococcal infection will spread in the subcutaneous tissue, causing a wide-spread, perhaps fatal cellulitis, whereas, in a healthy subject, the intruders are fenced off by a wall, a pyogenic membrane, as it used to be called, holding them back until they die or are eliminated. Quite analogous to this is the action of the tissues in fighting and fencing out the tubercle bacillus, and hence the explanation of the fact, long known and acted on, that general treatment, good food, pure air, out-door life, etc., etc., are the great aids in combating the disease.

I will say nothing here as to the means of treatment suggested by the discovery of the true nature of tuberculosis, merely remarking that this is no empty theory, but will bear fruits in the actual treatment of disease.

I have a few words, however, to say in regard to the sputa. It is evident that these should be carefully disinfected and rendered harmless. A thoroughly exhaustive series of experiments by Schill and Fischer, show that the best means for disinfecting the fresh

sputa is to have in the spit-cup a quantity of five per cent. solution of carbolic acid equal in amount to that of the sputa. Sublimate solution is not efficient, because it acts only on the outside of the lumps of sputum, cooking them, so to speak, but not killing the bacilli on the inside. Baking or boiling of handkerchiefs or clothes which have been soiled will kill the bacilli in an hour, even when the clothes are thick.

I submit that an organized public opinion ought to be brought to bear against the disgusting habit of spitting on the floor of horse-cars and public places, and physicians certainly ought to attend to such matters in prescribing the hygiene and mode of life of their patients, especially among the poor and ignorant.

The frequent examination of the sputa is of the utmost importance in establishing the diagnosis, and very useful in watching the progress of the disease. There is no doubt that bacilli can almost always be found before the tuberculosis has made much progress, and the gradual diminution of their frequency and their final disappearance is the surest token of recovery. Gaffky has published the results of the investigation of fourteen cases, examined microscopically daily for some three months; of twelve patients' sputa, there were in all nine hundred and eighty-two examinations, each time of one slide from each patient daily. Bacilli were found nine hundred and thirty-eight times, and not found forty-four times. Most were severe cases, but some were without fever and had only slight infiltration of the apices, yet the bacilli were found in the latter.

In two cases, the bacilli diminished, were absent, returned, and finally disappeared altogether; one of these was discharged apparently cured; the other died of perforative peritonitis caused by swallowing eighteen

plum-stones. The lungs showed no caverns or cheesy deposits, but a calcified spot as large as a cherry stone, and slate-colored, fibrous induration of the apices.

I will only insist, on closing, on the great necessity for the disinfection of tuberculous sputa; for proper precautions to prevent infection of relatives or attendants of the phthisical; of the careful examination of our meat and milk supply, and of carefully treating any catarrhal conditions of the air-passages, as well as of generally keeping the system of those up to par who have any inherited disposition to tuberculosis.

Of the regular examination of tuberculous or suspected sputum, I will only say that it must become more and more common, like auscultation and percussion, until it becomes an essential part of every examination of the chest, making any pretence to thoroughness or scientific precision in patients suspected of tuberculosis.